Effects of Motorcycle Helmet Laws on Fatalities' Prevention: An Impact Evaluation

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Abstract

Simultaneity bias complicates the estimation of the causal effect of motorcycle helmet usage on fatalities. We overcome this obstacle by exploiting an exogenous variation in the enforcement of the motorcycle helmet usage law between two municipalities in Uruguay. We show evidence of a dramatic increase in helmet usage in one municipality after the law was enforced. In just one month, usage increased from less than 10% to more than 90%. Our difference in difference estimates show that helmet usage laws are associated with a significant decrease in injuries and fatalities.

Resumen ejecutivo

¿Es efectivo el uso del casco para reducir la gravedad de las lesiones? La literatura científica internacional ha estudiado este tema pero sólo para países desarrollados. En América Latina, los accidentes de tránsito son la principal causa de fallecimientos entre los jóvenes de 15 a 29 años. Uruguay es un país particularmente relevante: mientras Canadá, Finlandia y España presentan tasas de muertes por accidentes de tránsito de 0,7 cada 100 mil habitantes, Uruguay tiene una tasa de 8,8 (magnitud representativa de los países latinoamericanos, a excepción de Chile). Aprovechando la discontinuidad en la obligatoriedad del casco entre dos departamentos de Uruguay, encontramos, empleando una metodología de diferencias-en-diferencias, que el uso del casco logra reducir las lesiones graves y muertes en motociclistas en un 57%. Concluimos el estudio mostrando la robustez de los resultados y haciendo un análisis de los costos y beneficios monetarios de implementar la obligatoriedad del uso del casco.

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1. Introduction

According to the World Health Organization[5], 1.25 million people die each year as a result of road traffic crashes. Road traffic injuries are the first cause of death among people aged between 15 and 29 years. Almost half of those dying on the world's roads are "vulnerable road users": pedestrians, cyclists, and motorcyclists.

In the absence of constant action, road traffic crashes are predicted to become the seventh leading cause of death by 2030. However, the newly adopted 2030 Agenda for Sustainable Development has set an ambitious target of halving the global number of deaths and injuries from road traffic crashes by 2020.

There is a great heterogeneity in terms of rates of motorcycle fatalities among countries. Table 1 reports that Uruguay shows one of the worst rates in motorcycle accidents.

Table 1 - Rate of fatalities in motorcycle accidents

Rate per hundred thousand of fatalities in Motorized two-wheelers accidents[6].

Country	2014	
Canada	0,5	
Denmark	0,5	
Finland	0,5	
Israel	0,5	
Switzerland	0,7	
Germany	0,8	
Japan	0,8	**0 - 1,5**
Lithuania	0,8	
Spain	0,8	
Chile	0,9	
Australia	1,0	
Hungary	1,1	
France	1,2	
United States	1,6	
Korea	2,0	**1,5 - 3**
Greece	3,0	
Guyana	3,2	**3 – 4,5**
Marocco	4,4	
Guatemala	4,8	**4,5 - 6**
China	5,1	
Brazil	6,6	**6 – 7,5**
Colombia	7,4	
Uganda	8,4	**7,5 - 9**
Uruguay	**8,8**	

[5] See more: http://www.who.int/mediacentre/factsheets/fs358/en/

[6] Source: http://roads.live.kiln.digital/?lang=es#deaths

Paraguay	11,2	9 +
Cambodia	12,3	
Malaysia	14,9	
Thailand	26,3	

In this study, we present new evidence on the effectiveness of both motorcycle helmets and state laws that mandate their use.

We study the causal effect of mandatory helmet usage laws on fatalities in motorcycle accidents, using a natural experiment in Uruguay. A sharp change in the enforcement of the law in one municipality, and not in another one, allows us to work with a difference-in-difference framework. The enforcement of the law lead to a stunning increase in helmet usage (from less than 10% to more than 90% in just one month). This exogenous variation significantly reduced the probability of seriously injured or fatalities by 8.7 percentage points, a 57% reduction relative to the control group. We also find that this reduction goes hand in hand with an increase in the percentage of slightly injured, while the percentage of unharmed and the total number of motorcycle accidents didn´t change. Our results have policy implications regarding the effects of enforcing helmet usage laws on the health of the population.

The effectiveness of the motorcycle helmet at reducing the severity of injuries might seem uncontroversial. However, several factors could challenge the anticipated health benefits. First, the "Peltzman hypothesis" suggests that health benefits of helmet use might be attenuated by compensating changes in other risky driving behaviors (Peltzman, 1975). In other words, if drivers are compelled to wear a helmet, they may adjust their risk-taking on other margins (e.g., speed and braking distance). Second, the beneficial effects of the helmet use may be attenuated because motorcyclists, even in the absence of a helmet law, may already tend to use helmets in circumstances where they are most effective. That is, helmet laws may encourage helmet use on margins where they are least effective. Third, motorcycle helmet use might decrease rider vision and the time of reaction, and so increase both the likelihood and the severity of injuries (Liu et al., 2008). Fourth, helmet use may be ineffective at preventing injuries in the most serious crashes simply because the bodies of motorcyclists are otherwise so exposed (Dee, 2009). Fifth, the weight of a helmet might exacerbate certain types of injuries (i.e. those in the neck) (Dee, 2009). Sixth, ideologies that emphasize the value of individual choice make that helmet laws lead to a loss in personal utility that is non-trivial (Homer and French, 2009).

Also, though some literature shows that helmets decrease the probability to suffer injuries or fatalities (Branas, and Knudson, 2001; Ichikawa, Chadbunchachai, and Marui, 2003; Liu et al, 2008; Keng, 2005; Peng et al, 2017), it was no able to cope with endogeneity (those riders who use helmets may be also more careful at driving).

Peng et al. (2017) provides a broad literature review of recent research on the effects of helmets laws in USA. A total of 60 U.S. studies qualified for inclusion in their review. Implementing universal helmet laws increased helmet use (median, 47 percentage points); reduced total deaths (median, –32%) and deaths per registered motorcycle (median, –29%); and reduced total injuries (median, –32%) and injuries per registered motorcycle (median, –24%). Repealing universal helmet laws decreased helmet use (median, –39 percentage points); increased total deaths (median, 42%) and deaths per registered motorcycle (median, 24%); and increased total injuries (median, 41%) and injuries per registered motorcycle (median, 8%).

There was great variation in study designs and quality. In general, the methodological quality was poor. Most studies were either affected by selection bias or had the potential for this to influence their results. The majority of identified studies were cross-sectional designs that examined one or more of the outcomes (head injury, mortality, and facial injury or neck injury) in relation to helmet use, with a large number that only take into consideration fatalities, and not serious injuries. Most studies were based on populations from developed countries.

There are two papers from the economic literature more closely related to our work. Dee (2009) studies the effectiveness of helmet use and state laws that mandate helmet use in reducing motorcyclist fatalities. Using a within-vehicle fixed effect estimation, he finds that the technological effect of helmet use is a reduction of fatality risk by 34%. He also finds that state laws requiring helmet use appear to reduce motorcyclist fatalities by 27%. French, Gumus and Homer (2009) study the effectiveness of traffic policies in reducing motorcycle fatalities. Using state level data from 1990 to 2005, they find that universal helmet laws led to a 24% reduction in fatal motorcycle injuries. Both studies use data from the United States, where the rate of fatalities in motorcycle accidents is much smaller than in developing countries (Table 1). In particular, the Uruguayan rate is more than 5.5 times higher than in USA. Thus, our study may provide a more relevant estimate of the impact of universal helmet laws for developing countries, where the prevalence of deaths from motorcycle accidents is higher.

2. Background

Why is helmet needed?

As stated by the World Health Organization during a motorcycle or bicycle crash there are two main mechanisms that cause brain traumas: the direct contact and the acceleration and deceleration.

When a motorcycle or bicycle is involved in a collision, the rider is often thrown from the cycle. The motorcyclist that does not use helmet has a higher risk of suffering some kind of traumatic brain injury or a combination of it. Helmets create an additional layer for the head and thus protect the wearer from some of the more severe forms of traumatic brain injury

A helmet works in three ways. In the first place, it reduces the deceleration of the skull, and hence the brain movement, by managing the impact. The soft material incorporated in the helmet absorbs some of the impact and therefore the head comes to a halt more slowly. This means that the brain does not hit the skull with such great force. Secondly, it spreads the forces of the impact over a greater surface area so that they are not concentrated on particular areas of the skull. Finally, it prevents direct contact between the skull and the impacting object by acting as a mechanical barrier between the head and the object. These three functions are met, by combining the properties of four basic components of the helmets: *The shell* is the strong outer surface of the helmet that distributes the impact over a large surface area, and therefore lessens the force before it reaches the head. *The impact-absorbing liner*, which is made of a soft, crushable padded material, this dense layer cushions and absorbs the shock as the helmet stops and the head tries to continue moving. *The comfort padding* is the soft foam-and-cloth layer that sits next to the head. It helps keep the head comfortable and the helmet fitting snugly. *The retention system, or chin strap* is the mechanism that keeps the helmet on the head in a crash.

Riders who do not wear helmets place additional costs on hospitals, as consequence of staying in the hospital longer, greatest number of medical and surgical interventions and recovery time, while the disability that results from these head injuries incurs costs at an individual, family and societal level[7].

TABLE 2 – PROBABILITY OF SERIOUS INJURY USING HELMET

Dependent variable: Serious injury				
	(1)	(2)	(3)	(4)
Variables	Logit coeff	Logit coeff	Odd ratio	Odd ratio
Helmet	-0.391***	-0.429***	0.676***	0.651***
	(0.141)	(0.162)	(0.0952)	(0.105)
Constant	-2.449***	-3.181***	0.0864***	0.0415***
	(0.0716)	(1.115)	(0.00618)	(0.0463)
Observations	3,972	2,994	3,972	2,994
Controls	No	Yes	No	Yes

*** p<0.01, ** p<0.05, * p<0.1
Source: UNASEV (Unidad Nacional de Seguridad Vial, Uruguay).
Data: period 2013-2015
Notes: All regressions are run at the individual level. Helmet is a dichotomous variable equal to 1 if the person involved in the accident was wearing a helmet. Controls include a dummy for school

[7] “Helmets: A road safety manual for decision-makers and practitioners”. – World health organization

and public holidays; the interaction of hour with day; year and week of the accident. Standard errors are in parentheses.

In Table 2 we show, using our data, that the usage of a helmet is correlated with a significant reduction in the probability of being seriously injured in motorcycle accidents. Nonetheless, these estimates do not account for the endogeneity of using a helmet. A motorcyclist takes several decisions when he is going to ride his motorcycle: the speed, stopping at street crossings, respecting traffic signs, whether or not he is going to drive under the effects of alcohol or drugs, and if he will be wearing a helmet. Thus, helmet usage is an (endogenous) choice variable. Riders who decide to use a helmet self-select themselves into the treatment, so there can be unobservable factors that confound the use of a helmet and the severity of an accident. In the next sections of the paper we will try to estimate the causal effect of using a helmet on the probability of serious injuries and fatalities.

The Uruguayan natural experiment

On November 2007, the parliament approved law No. 18.191, the National Law of Traffic, becoming mandatory wearing helmet for the users of motorcycles, at national level. However, neither Mercedes -the capital city of Soriano- nor Melo -the capital city of Cerro Largo- decided to monitor the use of helmet, not following the national law of road safety, arguing that transit issues respond to departmental jurisdiction as propounded in the Constitution. As Table 3 reports, the percentage of people using helmet over the people affected by an accident was 7.9% and 21.2% for Soriano and Cerro Largo (two out of 19 departments of Uruguay) respectively. There is variation between the different cities of the same department. Moreover, the usage of helmet was smaller (almost non-existent) in the cities of Mercedes and Melo than in the rest of the cities of their department, with respectively 3.1% and 5.7%. These will be our pre-treatment helmet usage figures.

Table 3

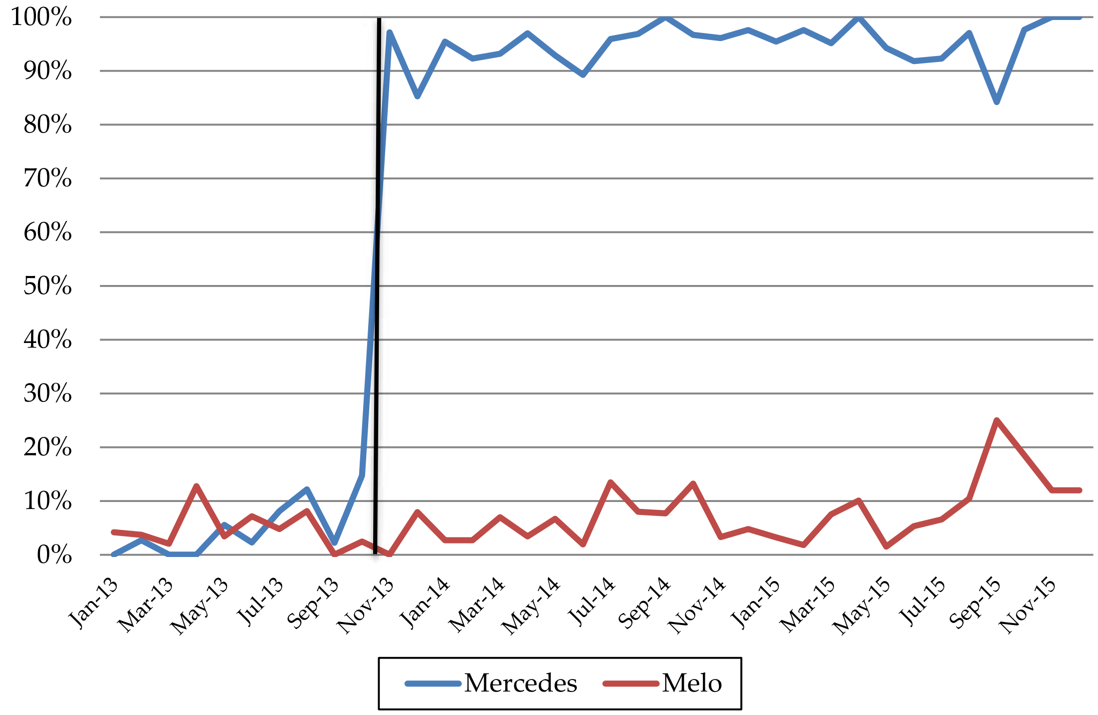
	January-July 2013
Soriano	7,9%
(Mercedes)	(3.1%)
Cerro Largo	21,2%
(Melo)	(5.7%)
Canelones	53,7%
Colonia	55,4%
Durazno	59,8%
Paysandú	69,4%

Tacuarembó	70,1%
San José	71,7%
Rocha	80,6%
Flores	83,7%
Montevideo	84,1%
Treinta y Tres	85,0%
Maldonado	87,8%
Florida	88,0%
Rio Negro	89,3%
Lavalleja	90,4%
Salto	90,7%
Artigas	94,9%
Rivera	96,1%

On August 2013, Parliament approved law No. 19.120 – the Misdemeanors Act, which include an article establishing a punishment for not using the helmet, consisting of community work. The police are responsible for enforcing it, due to it is a national level law. Since the misdemeanors act was approved, the Mayor of Soriano gradually let people know that he would enforce the national law of traffic employing the misdemeanors act. Based on that, on November 1, 2013, the municipality of Soriano starts monitoring the use of helmet, while Cerro Largo remained steadfast in its position of not follow the national law of road safety.

We take as our pre-treatment moment the period January – July 2013 because, during this sample period, the Mayor of Soriano did not make any statement nor deliver any hint in favor of the application of the national law of traffic.

FIGURE 1 – PERCENTEGE OF PEOPLE WEARING HELMET IN MOTORCYCLE ACCIDENTS



Notes: By locality, monthly average of the percentage of people wearing helmet in motorcycle accidents. The black vertical line indicates the starting of the treatment.

We concentrate our analysis in Mercedes and Melo, that is, the capitals of Soriano and Cerro Largo respectively, which are the most populated urban regions of these two departments of Uruguay. Figure 1 shows a stunning increase in the usage of helmets after the law was enforced. It is remarkable how motorcycle riders started wearing helmets as a result of the policy change. We think that this dramatic increase in usage is exogenous and not correlated with riders' preferences on health nor on riding style or other unobservable variables. This increase in usage will be the source of exogenous variation for our main estimates.

Finally, we should note that data on helmet usage is not self-reported: it comes from actual accidents where police verifies helmet usage. So Figure 1 accurately reflects the usage of helmet in our Treatment and Control municipalities.

3. Data

The data used in this report is drawn mainly from the database of UNASEV (Unidad Nacional de Seguridad Vial / National Division of Road Security). The database has detailed information, about the accidents where police intervened, on the date, hour and location of the accident. The database includes information about the people involved in the accident, such as age, gender, role in the accident: if the person was passenger or driver, reason of the accident, consequence of the accident: death, serious injury, slight injury or unharmed, and if the person wears helmet or seat belt if applicable. While the report is filled by the police that intervened in the accident, the variable that explains the consequence of the accident is filled by the medical assistance. They are the responsible to identify if the person is slightly or seriously injured, and the difference lies in if the person has vital organs compromised. Regarding to the death as consequence of the accident, the dataset specify if the fatality is where the accident took place or at the medical center, and, in the latter, it counts if the person dies 30 days counting forward from the day of the accident

In addition to the main dataset, we collect daily time of sunset information, to create a dichotomous variable equals one, if the accident occurs at night. Additionally we collect daily holiday's information that include national holidays, as well as school holidays, which could potentially affect both traffic volume and accidents. Table 4 displays the definition of key variables in the dataset.

TABLE 4 - DEFINITION OF VARIABLES

Variables	Definition
Night	Dichotomous variable equals 1 if the accident occurs during the night.
Helmet	Dichotomous variable equals 1 if the person involved wears helmet.
Holiday	Dichotomous variable equals 1 if the day of the accident is a school or public holiday.
Hour*	Dichotomous variable equals 1 if the hour of the accident is *.
Day*	Dichotomous variable equals 1 if the day of the accident is *.
Week*	Dichotomous variable equals 1 if the week of the accident is *.
Year*	Dichotomous variable equals 1 if the year of the accident is *.
Seriously injured or killed	By motorcycle, the number of seriously injured or killed where the accident took place or at the medical center.
Mercedes	Dichotomous variable equals 1 if the accident took place in the locality of Mercedes.
Melo	Dichotomous variable equals 1 if the accident took place in the locality of Melo.

3.2. Description of localities

TABLE 5 – DESCRIPTION OF LOCALITIES

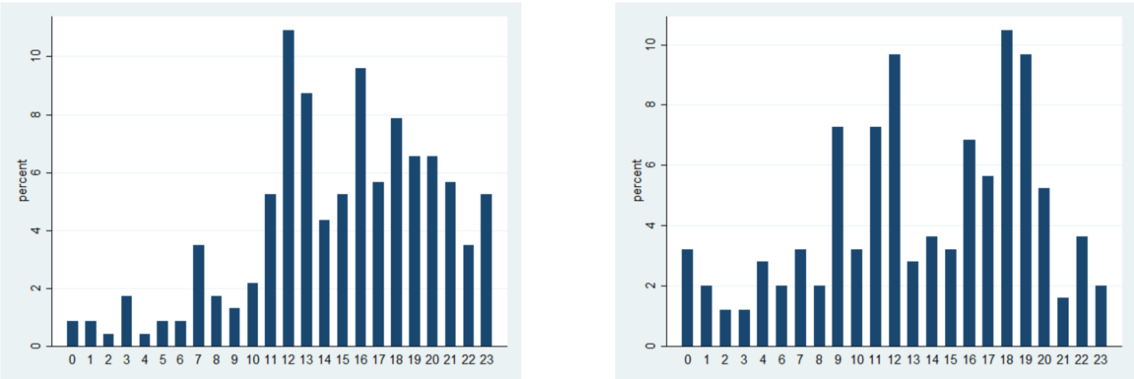
	Mercedes	Melo
Total population	41,974	51,830
Total number of motorcycle or moped	45,157	44,181
Total number of automobile or van	14,956	19,179
Number of motorcycle or moped per capita	1.076	0.852
Number of automobile or van per capita	0.356	0.370

Notes: Data by Nacional Census 2011.

FIGURE 2 - PEOPLE AFFECTED BY A MOTORCYCLE ACCIDENT (percentage by hour of the day)

Panel A. Mercedes

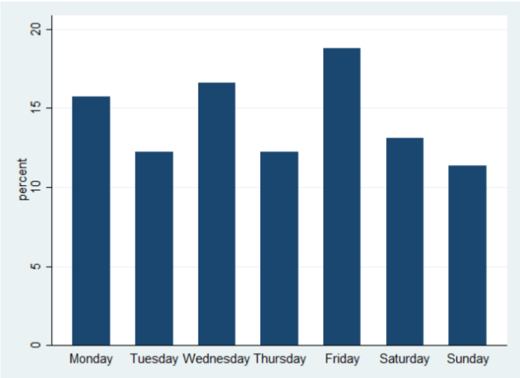
Panel B. Melo



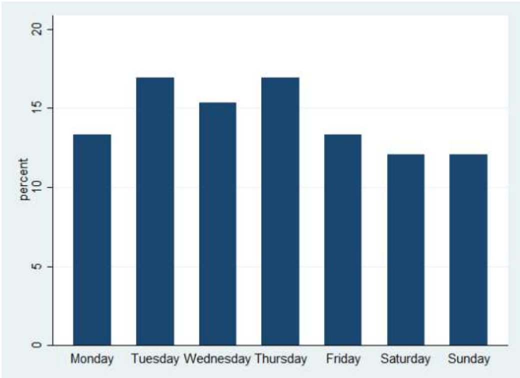
Notes: The blue bars show the percentage per hour of people affected by a motorcycle accident in the pre-treatment period January – July 2013.

FIGURE 3 - PEOPLE AFFECTED BY A MOTORCYCLE ACCIDENT (percentage by day of the week)

Panel A. Mercedes



Panel B. Melo



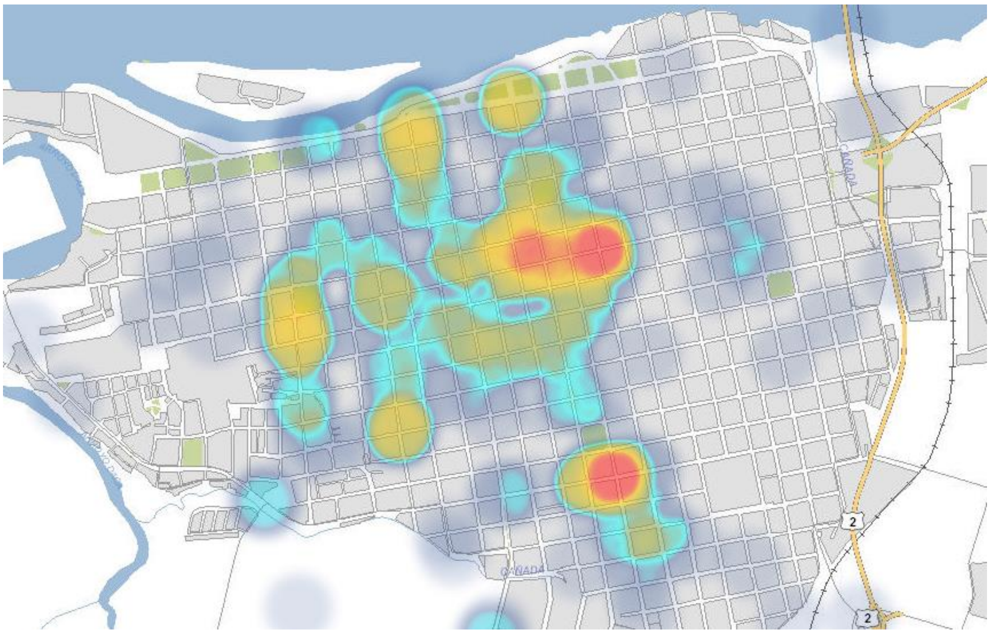
Notes: The blue bars show the percentage per day of people affected by a motorcycle accident in the pre-treatment period January – July 2013.

Figures 2 and 3 illustrate the distribution of people affected by a motorcycle accident across time and space. We observe that the percentage of people affected by a motorcycle accident does not have a wide variation among days of the week, especially in the location of Melo. However it presents a variation regarding the hours of the day. In both localities we observe a three pronounced spikes, at noon, mid-afternoon and late-afternoon; still there is not at the same hour in both localities.

FIGURE 4 – HEAT MAP OF ROAD ACCIDENTS

Panel A. Melo

Panel B. Mercedes



Notes: Colors indicates de density of road traffic accidents that involves motorcycles, being red high density, yellow medium density and blue low density, in the pre-treatment period January – July 2013. Data obtained from UNASEV.

In figure 4, we show that the distribution of the accident on both localities is not homogeneous.

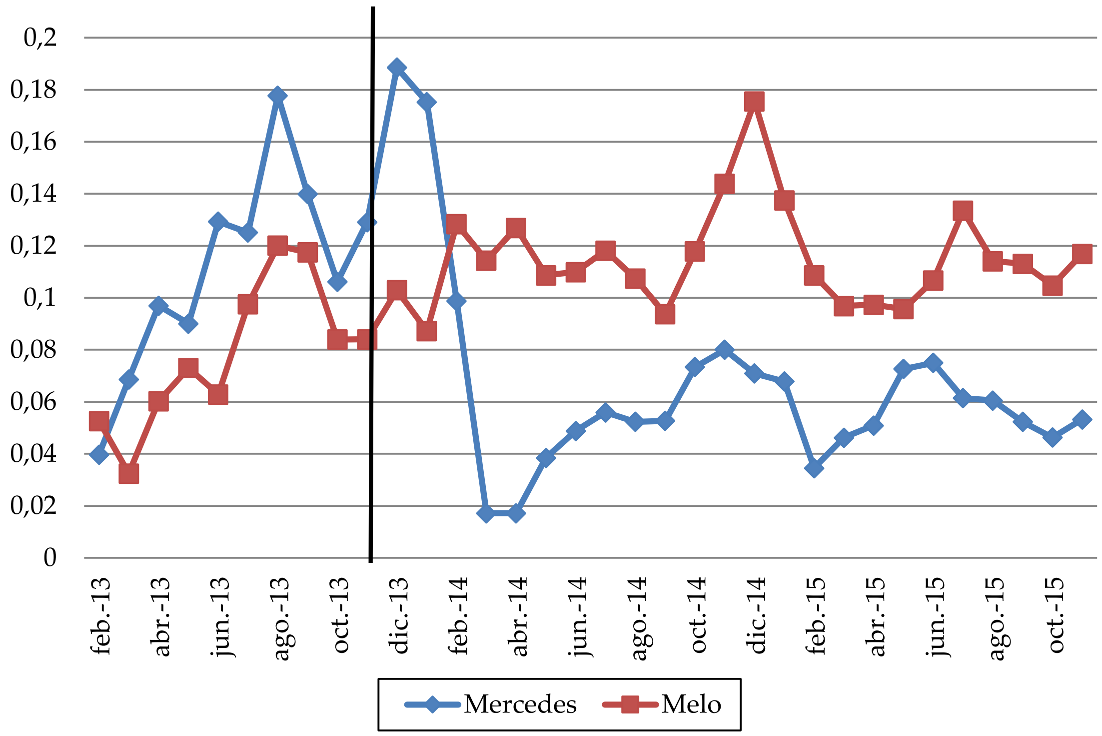
TABLE 6 – DESCRIPTIVE STATISTICS of MOTORCYCLE ACCIDENTS at PRE-TREATMENT

Variables	Mercedes Mean	Mercedes SD	Mercedes Obs.	Melo Mean	Melo SD	Melo Obs.	Mean Differences
Age	31.624	16.113	221	28.136	14.333	243	-3.489** (-2.47)
Unharmed	0.362	0.482	229	0.202	0.402	248	-0.161*** (-3.97)
Slight injury	0.559	0.498	229	0.746	0.436	248	0.187*** (4.37)
Serious injury	0.079	0.270	229	0.044	0.206	248	-0.0342 (-1.56)
Fatalities	0.000	0.000	229	0.008	0.090	248	0.00806 (1.36)
Accidents at night	0.319	0.467	229	0.242	0.429	248	-0.0768* (-1.87)
Male	0.629	0.484	229	0.652	0.477	247	0.0230 (0.52)
Run over an animal	0.000	0.000	229	0.069	0.253	248	0.0685*** (4.10)
Run over a pedestrian	0.031	0.173	229	0.028	0.166	248	-0.00234 (-0.15)
Fall over	0.205	0.405	229	0.173	0.379	248	-0.0319 (-0.89)
Single-vehicle collision (excludes run-off-road)	0.031	0.173	229	0.016	0.126	248	-0.0144 (-1.05)
Collision (between vehicles)	0.734	0.443	229	0.710	0.455	248	-0.0239 (-0.58)
Run-off-road collisions	0.000	0.000	229	0.004	0.064	248	0.00403 (0.96)
Helmet	0.031	0.173	229	0.057	0.232	246	0.0263 (1.40)

* p<0.1, ** p<0.05, *** p<0.01

Notes: Table lists the mean difference between the locality of Mercedes and Melo, in the pre-treatment period January – July 2013.

FIGURE 5 – PERCENTEGE OF SERIOUSLY INJURED OR FATALITIES BY MOTORCYCLE

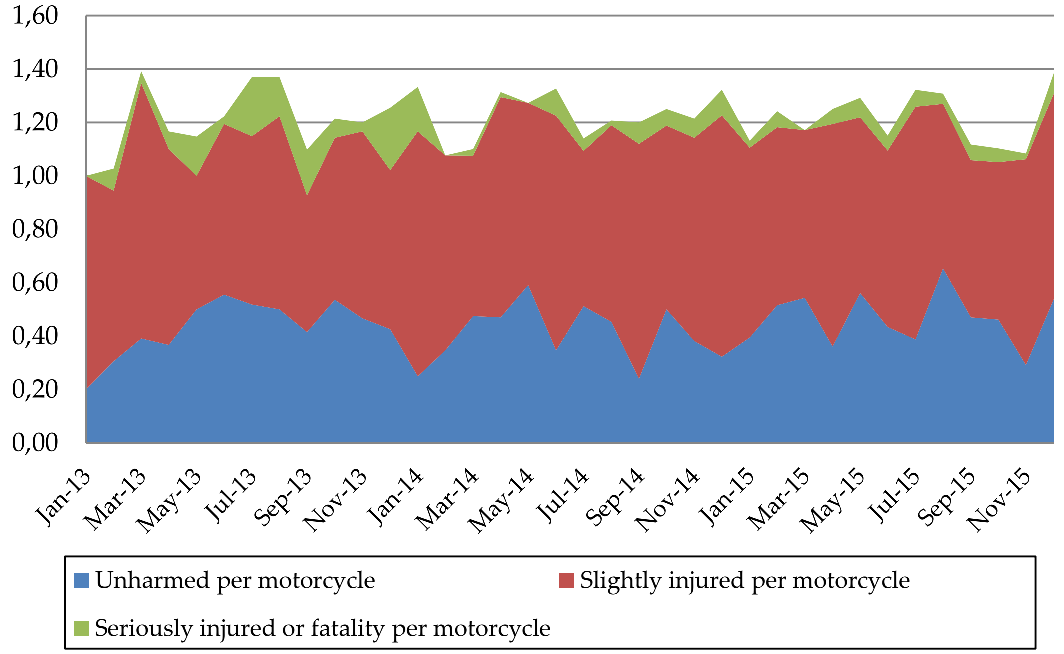


Notes: Monthly average of the number of seriously injured or fatalities where the accident took place or at the medical center by motorcycle. The black vertical line indicates the starting of the treatment.

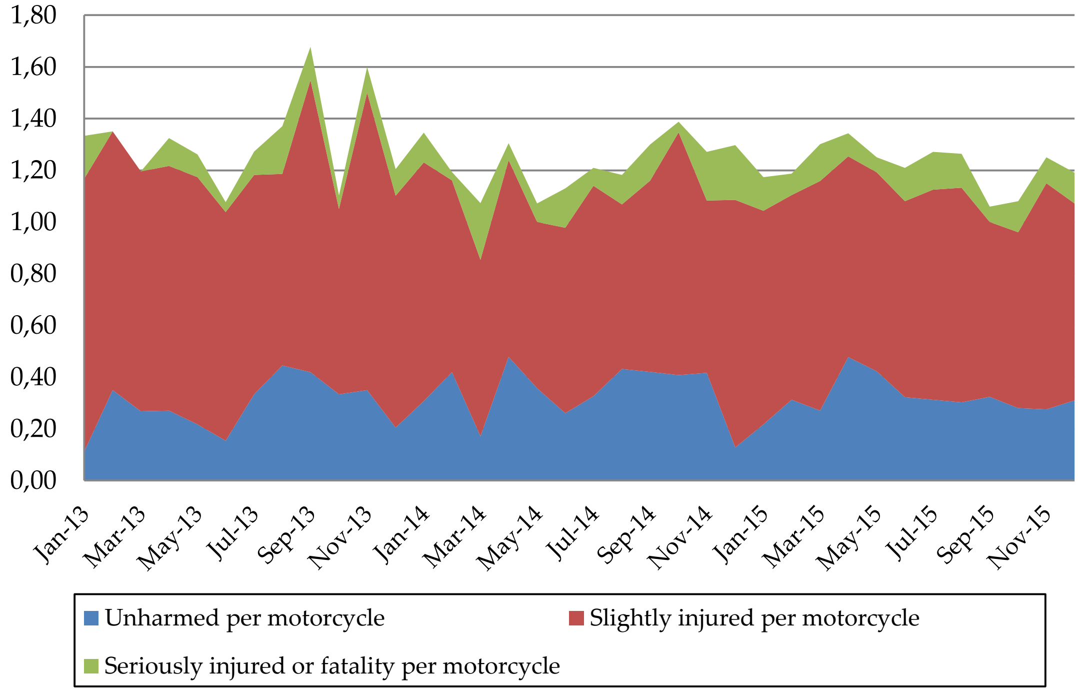
Figure 5 displays our main result from the difference in difference approach. We see that before the treatment (vertical line on November 2013), the trends between Mercedes (Treated) and Melo (Control) were the same, while in levels Mercedes had slightly higher percentage in the severity of accidents. In the post-treatment period, when helmet usage law was enforced in Mercedes, we clearly see a decrease in the probability of seriously injured or fatalities in motorcycle accidents relative to Melo. In the next sections we will formally estimate the exact impact of the law, using dif-in-dif regression. At this point, nonetheless, it is reassuring to see from figure 1 and figure 6 that the policy had a clear impact in helmet usage (Figure 1) which led to a reduction in the severity of accidents (Figure 6).

FIGURE 6 – PERCENTEGE OF UNHARMED, SLIGHTLY INJURED, SERIOUSLY INJURED OR FATALITIES BY MOTORCYCLE.

Panel A. Mercedes



Panel B. Melo



Notes: Monthly average of the number of unharmed, slightly injured, seriously injured or fatalities where the accident took place or at the medical center per motorcycle in the period January 2013 – December 2015.

Figure 6 shows the evolution of the three possible outcomes of a motorcycle accident: unharmed, slightly injured and seriously or fataly injured. We illustrate how in the locality of Mercedes the monthly average of seriously injured or fatalities decreases after November 1st, while this number increases in the locality of Melo in the same period. Moreover, the monthly average of slightly injured increases in the locality of Mercedes, while the number decreases in the locality of Melo, after the treatment. A change in the number of unharmed is not observed in none of the two panels.

4. Methodology

Our identification strategy is based on a Difference in Difference regression model, which compares the proportion of seriously injured and fatalities per motorcycle in each city, before and after the intervention period. We estimate the following specification as follows:

$$Y_{it} = \alpha + \beta(Mercedes_i XAfter_t) + \gamma Mercedes_i + \partial After_t + \delta Holidays_{it} + \theta_h + \mu_d + \rho_w + \vartheta_y + \epsilon_{it}$$

Where Y_{it} is the percentage of seriously injured and fatalities by motorcycle in the accidents *i* produced at time *t* (where *t* indicates each hour of the day); MercedesXAfter is a dichotomous variable equal to 1 when the accident took place in Mercedes during the treatment period; Mercedes is a binary variable equal to 1 when the accident occurred in Mercedes city; Holidays is a dichotomous variable that takes the value of 1 if the day of the accident is school or public holiday. We also include a full set of day-of-week-specific fixed effects (μ_d), hour-of-day fixed effects (θ_h), week-of-year fixed effects (ρ_w) and year fixed effects (ϑ_y).

5. Results

TABLE 7 – THE IMPACT OF THE APPLICATION OF THE LAW ON THE USE OF HELMET

Dependent variable: Takes the value 1 if the person in the accident wears a helmet and 0 otherwise		
Variables	(1)	(2)
Mercedes X After	0.874***	0.872***
	(0.0194)	(0.0194)
Mercedes	0.00972	0.00974
	(0.0173)	(0.0173)
After	0.0246*	0.0167
	(0.0133)	(0.0260)
Constant	0.0479***	0.112***
	(0.0123)	(0.0402)
Observations	4,004	4,004
R-squared	0.743	0.755
Controls	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Data: period 2013-2015

Notes: Standard errors in parentheses. The variable Mercedes X After is a dummy that takes the value 1 when the accident took place in Mercedes after November 1st. The variable Mercedes equals 1 if the accident took place in Mercedes and After is a dichotomous variable that equals 1 if the accident occurred after November 1st. Controls include a dummy for school and public holidays; a full set of day-of-week-specific fixed effects, hour-of-day fixed effects, week-of-year fixed effects and year fixed effects.

Table 7 shows the results of a "First Stage" (the impact of law enforcement on compliance with the use of helmets). These estimates are consistent with Figure 1. Helmet usage significantly increased from a base of 4.8% in Melo before treatment to 95.6% in Mercedes after treatment.

TABLE 8 – THE EFFECT OF HELMET USE ON SERIOUS INJURIES AND FATALITIES

Dependent variable: percentage of seriously injured or fatalities by motorcycle		
	(1)	(2)
Variables		
Mercedes X After	-0.0840***	-0.0865***
	(0.0302)	(0.0307)
Mercedes	0.0331	0.0378
	(0.0266)	(0.0270)
After	0.0359*	0.0539
	(0.0209)	(0.0418)
Constant	0.0793***	0.142**
	(0.0186)	(0.0666)
Observations	2,381	2,381
R-squared	0.006	0.036
Controls	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Data: period 2013-2015

Notes: Standard errors in parentheses. The variable Mercedes X After is a dummy that takes the value 1 when the accident took place in Mercedes after November 1st. The variable Mercedes equals 1 if the accident took place in Mercedes and After is a dichotomous variable that equals 1 if the accident occurred after November 1st. Controls include a dummy for school and public holidays; a full set of day-of-week-specific fixed effects, hour-of-day fixed effects, week-of-year fixed effects and year fixed effects.

In table 8, we show that the treatment has a negative and significant impact on the number of seriously injured or fatalities per motorcycle accident. Our reduced form estimates show that helmet usage laws reduce the probability of seriously injuries or fatalities by 8.7 percentage points (a 57% reduction relative to what would have happened in the control city of Melo).

TABLE 9 – TESTING THE PARALLEL TRENDS ASSUMPTION

	Dependent variable: percentage of seriously injured or fatalities by motorcycle
Mercedes X Months	0.00282
	(0.0114)
Mercedes	0.0253
	(0.0768)
Months (coded as 1 to 10)	-0.0832
	(0.0804)
Constant	1.018
	(0.811)
Observations	529
R-squared	0.093
Controls	Yes

*** p<0.01, ** p<0.05, * p<0.1

Date: January-July 2013

Notes: Each observation corresponds to an accident and the dependent variable is calculated as the percentage of seriously injured or fatalities by motorcycle in each accident. The analysis uses data for Mercedes and Melo, prior to the start of the helmet control in Mercedes (with the 10 months of data being as Months 1 to 10). Standard errors in parentheses. Controls include a dummy for school and public holidays; a set of day-of-week-specific fixed effects, time range-of-day fixed effects and week-of-year fixed effects.

We test for parallel trends before the intervention and find that we do not reject the null hypotesis of parallel trends, with the coeffcient on the interaction term being close to zero (Table 7). We also estimate an alternative regression for testing the parallel trends assumtions, employing interaction terms (Mercedes X Month) for each month. We also do not reject the null hypotesis of parallel trends. Results are available upon request.

TABLE 10 – NUMBER OF ACCIDENTS

Dependent variable: total number of accidents in a month		
	(1)	(2)
Variables		
Mercedes X After	-5.931	-5.931
	(4.870)	(4.930)
Mercedes	-1.300	-1.300
	(4.138)	(4.189)
After	12.13***	10.02*
	(3.443)	(5.692)
Constant	27.10***	28.89***
	(2.926)	(5.863)
Observations	72	72
R-squared	0.246	0.250
Controls	No	Yes

*** p<0.01, ** p<0.05, * p<0.1
Data: period 2013-2015
Notes: Standard errors in parentheses. The variable Mercedes X After is a dummy that takes the value 1 when the accident took place in Mercedes after November 1st. The variable Mercedes equals 1 if the accident took place in Mercedes and After is a dichotomous variable that equals 1 if the accident occurred after November 1st. Controls include year fixed effects.

As we express in the introduction, even when it seems intuitive that helmets should protect against head injuries, it has been argued that motorcycles helmet use decrease rider vision what ends in a major number of accidents. In table 10, we reject that hypothesis: we find no significant change in the monthly total number of accidents.

Also, Table 10 provides us with some evidence that the findings about the effect of enforcement of helmets on fatalities and serious injuries is not just the result of confounders. If the reduction in fatalities and serious injuries were the result of a contemporaneous change in the general enforcement of the national law of traffic in Mercedes, we should have find that the number of accidents had declined, but it is not the case. What we have found is that, even in the presence of the same quantity of accidents, the number of fatalities and serious injuries in motorcycles' accidents decreased in Mercedes in comparison to Melo.

TABLE 11 – THE EFFECT OF HELMET USE ON SLIGHT INJURIES AND UNHARMED

Dependent variable: (1) percentage of slightly injured / (2) unharmed by motorcycle		
	(1)	(2)
Variables		
Mercedes X After	0.143**	-0.0564
	(0.0607)	(0.0508)
Mercedes	-0.208***	0.155***
	(0.0534)	(0.0447)
After	-0.148*	0.0511
	(0.0826)	(0.0692)
Constant	1.110***	0.0658
	(0.132)	(0.110)
Observations	2,381	2,381
R-squared	0.031	0.050
Controls	Yes	Yes

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Data: period 2013-2015

Notes: Standard errors in parentheses. The variable Mercedes X After is a dummy that takes the value 1 when the accident took place in Mercedes after November 1st,, 2013. The variable Mercedes equals 1 if the accident took place in Mercedes and After is a dichotomous variable that equals 1 if the accident occurred after November 1st, 2013. Controls include a dummy for school and public holidays; a full set of day-of-week-specific fixed effects, hour-of-day fixed effects, week-of-year fixed effects and year fixed effects.

In Table 8, we had observed that using helmet reduces the severity of the injury, while Table 11 reports that the mentioned reduction of the severity goes hand in hand with: (a) an increase of the slightly injured (column 1), and (b) no changes in the number of unharmed (column 2).

The overall picture is that while the number of accidents (Table 10) and the number of unharmed (Table 11, col.2) remained constant, the policy reduced severe and fatal accidents (Table 8) and shifted them to slightly injured ones (Table 11, col.1).

TABLE 12 – PLACEBO TEST: THE EFFECT OF HELMET USE ON SERIOUS INJURIES AND FATALITIES IN CAR ACCIDENTS

Dependent variable: percentage of seriously injured or fatalities in car accidents		
	(1)	(2)
Variables		
Mercedes X After	-0.00151	-0.00222
	(0.00945)	(0.00968)
Mercedes	0.00365	0.00576
	(0.00849)	(0.00871)
After	-0.00168	0.00553
	(0.00649)	(0.0130)
Constant	0.00549	-0.00559
	(0.00585)	(0.0191)
Observations	1,803	1,803
R-squared	0.000	0.034
Controls	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Data: period 2013-2015

Notes: Standard errors in parentheses. The variable Mercedes X After is a dummy that takes the value 1 when the accident took place in Mercedes after November 1st, 2013. The variable Mercedes equals 1 if the accident took place in Mercedes and After is a dichotomous variable that equals 1 if the accident occurred after November 1st, 2013. Controls include a dummy for school and public holidays; a full set of day-of-week-specific fixed effects, hour-of-day fixed effects, week-of-year fixed effects and year fixed effects.

The enforcement of the use of helmet since November 1st, 2013 should not have any impact on the seriousness of injuries nor on fatalities in individuals driving cars in traffic accidents. Thus Table 12 provides a placebo test, and it confirms this hypothesis. Also, Table 12 offers another piece of evidence that our findings in favor of the helmet are not just the result of confounders like a contemporaneous variation in other traffic laws: if it were the case, the fatalities and serious injuries in car accidents should have decreased. Also we sought for any press news about other changes in the application of traffic laws in Mercedes and Melo in the sample period, but we have found no news.

6. Discussion

Motorcycle crashes account for a disproportionate number of motor vehicle deaths and injuries in many developing countries. Resistance to legislation on motorcycle helmets still coexists with debate on the effectiveness of motorcycle helmets in reducing morbidity and mortality. Using data for Uruguay, we show that it is possible to change habits regarding the usage of helmets. The enforcement of the law increased helmet usage from less than 10% to more than 90% in just one month. Using a difference in difference framework we have exploited this exogenous variation and found that wearing a helmet reduces the percentage of seriously injured and fatalities in motorcycle accidents. Our reduced form estimates suggest that helmet usage laws reduce the probability of serious injuries or fatalities by 8.7 percentage points (a 57% reduction relative to the control group).

Helmet laws lead to a loss in personal utility that is non-trivial. Because these costs cannot be easily quantified, it is not possible to credibly compare the costs and benefits of these regulations. However, our results do make it possible to frame the empirical magnitudes of the benefits of helmet laws in a way that may be useful for informed policy discourse. More specifically, in 2015, the five Uruguayan Departments with a helmet law compliance under 70 percent –that is, the Departments where more than 30 percent of the seriously injured or fatalities were not using helmets- experienced 985 seriously injured motorcyclist or fatalities. A quite conservative estimate for the value of a statistical life is $ 2 million dollars (Dee, 2009) and for the value of health costs is $ 7,437 dollars (Paolillo et al., 2016]). Considering that one in ten seriously injured ends in fatality and that a mandatory helmet law would reduce seriously injured and fatalities by 57% percent, the annual benefit of avoiding 561 seriously injured lives would be roughly $ 116 million dollars.

Inspired in Dee (2009) approach to monetary benefits analysis, we do the following estimate. On the cost side, there were roughly 459,000 registered motorcycles in the cited five Uruguayan Departments. Roughly 70 percent motorcyclists in these states wear helmets. Therefore, approximately 115,000 motorcyclists would be constrained by the universal expansion of helmet laws. Combining these results, the seriously injured saving effect of helmet laws would amount to $ 1,009 dollars benefit annually for each motorcyclist constrained by the enforcement of the law. Assuming a real discount rate of 5 percent and a 30-year time horizon (Dee, 2009), the present discounted value of this social benefit is roughly $ 17,000 dollars for each motorcyclist who would be required to wear a helmet because of a legal requirement. These figures provide a rough sense of the benefits of motorcycle-helmet laws in order to compare them with their social costs. It should be noted that these calculations ignored additional direct benefits (lost wages of the victims, physical therapy, rehabilitation, prosthetic devices, and lost lives in case of fatalities) and the external benefits of helmet use (legal fees and court costs, value travel delay for all road users, cost of workplace disruption that are due to the absence of a worker).

Dee (2009) suggests that the tension between public-health advocates and motorcyclists that emphasize the value of individual choice would diminish if they agree to a regulatory compromise that mandates helmet use (subject to secondary enforcement) but only for those who have not paid a Pigouvian fee that reflects the external costs of not using a helmet. Alternatively, the regulatory fee for non-use of a helmet could be a non-pecuniary act that makes a contribution to public health (e.g., becoming an organ donor). Alternative policies like this may provide a politically feasible and normatively attractive way to balance the external costs of not wearing a motorcycle helmet with other health-related or fiscal benefits.

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